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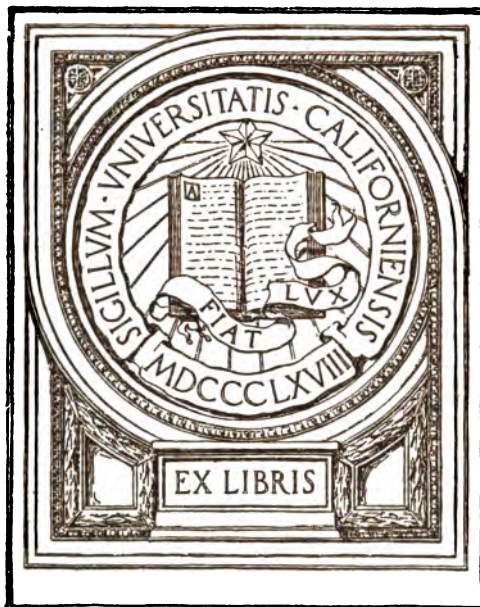
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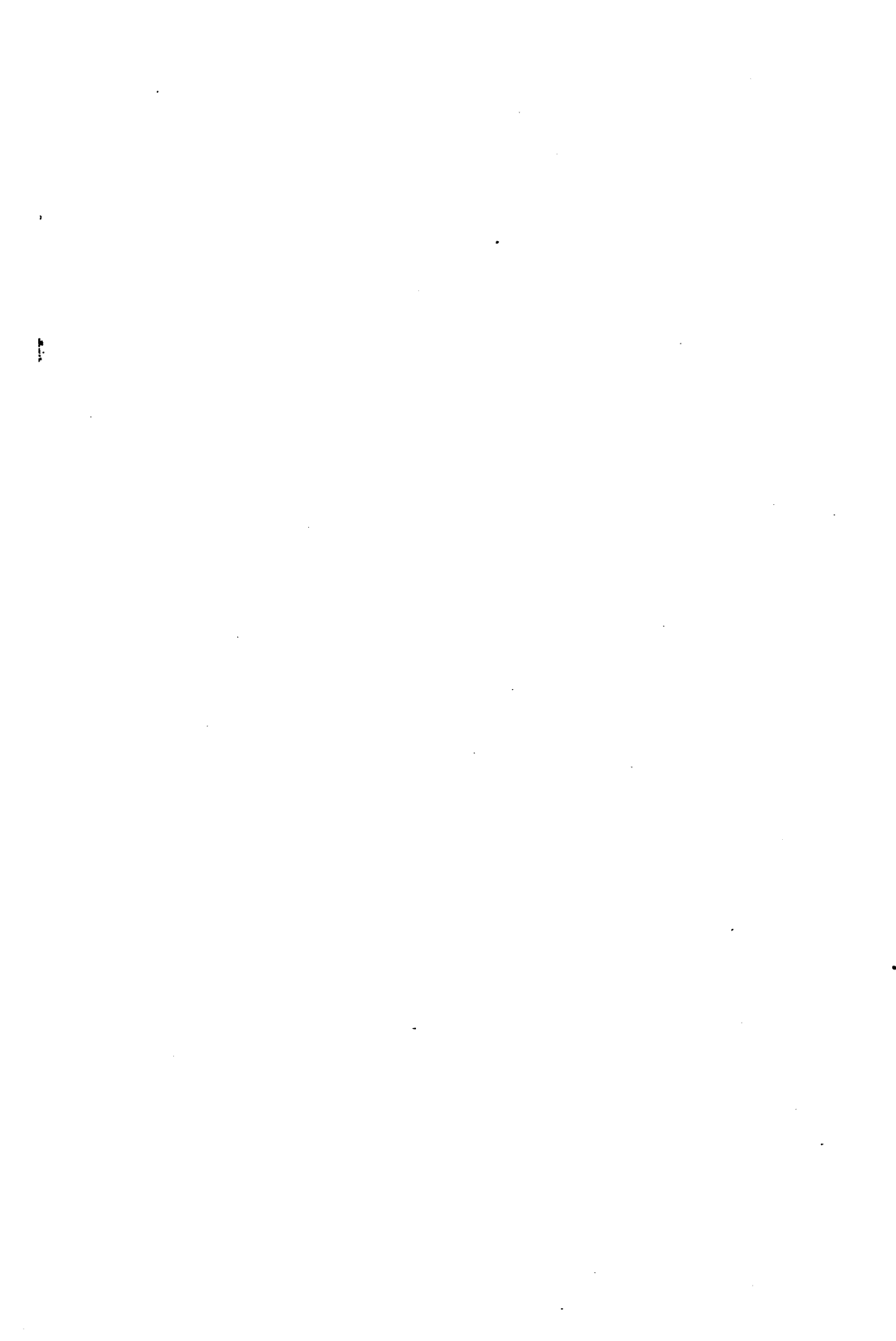
THE FUTURE OF OUR RAILWAYS

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*The Future of
Our Railways*



“ who shall place
A limit to the giant's unchained strength
Or curb his swiftness in the forward race? ”

—BRYANT

The Future of Our Railways

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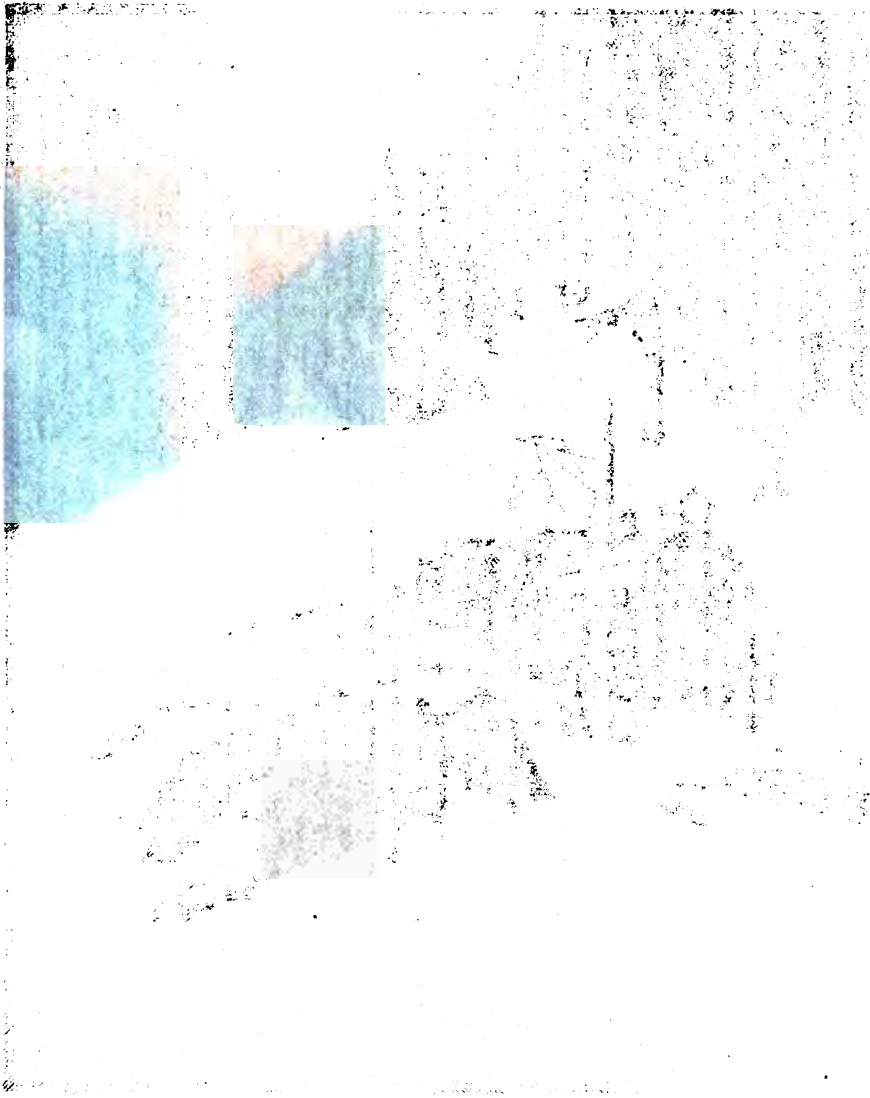


By
W. H. ARMSTRONG
MEMBER OF THE ELECTRICITY ADMINISTRATION COMMITTEE
GENERAL ELECTRIC COMPANY

Presented at the Forty-third
Annual Meeting of the National Electric Light
Association, Los Angeles, May, 18-22, 1920.

GENERAL ELECTRIC COMPANY

SCHENECTADY, N. Y., U. S. A.



“ . . . who shall place
A limit to the giant's unchained strength
Or curb his swiftness in the forward race?”

— RAY

The Future ^{UNIV. OF} of ^{CALIFORNIA} Our Railways



By
A. H. ARMSTRONG
CHAIRMAN ELECTRIFICATION COMMITTEE
GENERAL ELECTRIC COMPANY

Reprinted from a paper presented at the Forty-third
Annual Convention of the National Electric Light
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GENERAL VIEW OF GREAT FALLS DAM AND POWER HOUSE, CHICAGO, MILWAUKEE
& ST. PAUL ELECTRIFICATION

THE FUTURE OF OUR RAILWAYS

WITH the return of the railways on March 1st, the owners were confronted with general conditions never paralleled in history. The present gross income is insufficient to make any reasonable return on the capital invested, after meeting the greatly increased demands of labor. No funds are available to buy needed locomotives and cars, the government having failed to make such purchases during its period of control. The borrowing fund made available by the government may serve to dull the edge of immediate needs, but makes no provision for the future growth of traffic which in the past has doubled about every twelve years. Even assuming that a receptive market can be created for railway securities, private ownership can work no miracle where a government with unlimited funds has failed, if the rehabilitation of our railways is to be patterned after the same old lines. It is commonly accepted that our transportation system has fallen down, but an examination of the facts may lead to the conclusion instead

that the steam engine now used to haul our freight and passenger trains has fallen down.

The trouble with our railways is, perhaps, fundamentally deeper than the issues raised by increased cost of labor and material and lack of ready funds. As a matter of fact it is considered by many to be an engineering, rather than a strictly financial crisis that confronts us today, and that our transportation needs have outgrown the possibilities of the steam engine.

Two forces have been acting to bring about this point of view, a growing recognition of the limitations of the steam engine and the measure of comparison afforded in the marked success of electric locomotive operation on main lines. The electric locomotive has not merely replaced the steam engine and duplicated its past performance, but its freedom from the construction and operation restrictions imposed by burning fuel and generating steam has permitted a design of electric locomotive which has completely upset the operating traditions established in three generations of steam engine railroading. Judging the steam engine in the knowledge of electric locomotive operation provides the necessary perspective to arrive at the conclusion that the steam engine is inherently poorly adapted to meet the needs of modern railroading.

The trying period of war transportation brought the steam engine failure sharply into the public view and served to emphasize its complete inability to meet overloads or operate successfully under adverse climatic conditions. While the steam engine froze up during the unprecedented cold of the winter of 1917-18 with the disastrous results still fresh in mind, electric locomotives were unaffected and continued doing business as usual, hauling unreduced tonnage trains over mountain grades at twice the speed possible with steam engines.

No one likes to consider the cost of building additional tracks over our difficult mountain grades at present prices, but it is just here that the steam engine has most signally failed to meet requirements. It is not a good hill climber and the often used simile of the "neck of the bottle" is only too apt as applied to its mountain grade operation. The electric haulage of heavier trains at higher speeds increases the daily tonnage capacity of mountain divisions. Conservative estimates place this at 50 per cent greater than possible with the use of steam engines, thus making it feasible in many instances to electrify present tracks and to indefinitely postpone the need of expending huge sums for laying additional rails.

Unlike the steam engine, with its restricting boiler, the electric locomotive taps an unlimited supply of power through its trolley connection and can thus be built of any tractive power and speed demanded to meet the fulfillment of future transportation requirements. The possibilities opened up in this connection are hardly recognized at present, but in this respect the electric locomotive fully meets the modern demand for more power and still more power.

The steam engine is consuming one-quarter of all the coal mined in this country each year, in addition to six per cent of the oil, so unreplaceable for other purposes. The electric locomotive, however, can utilize water power, where available, or if dependent upon coal-fired generating stations, can haul the railway tonnage of the country with an expenditure of one-third the coal now consumed by the railway companies.

The safety of mountain railroading has been much enhanced by the introduction of electric braking provided by the electric locomotive on down grades. Not only are the air brakes thus entirely relieved of overheating and held in reserve, but the potential energy stored in the descending



GEARLESS PASSENGER LOCOMOTIVE WITH TRANSCONTINENTAL PASSENGER TRAIN
"OLYMPIAN" ASCENDING THE WESTERN SLOPE OF THE CASCADE RANGE

train is actually regenerated, delivered to the trolley system and made available for the use of some other train climbing a grade.

Finally, the electric locomotive has established new levels for low maintenance costs and reliability which with its greater flexibility in meeting the varied requirements of general transportation service contribute to place this type of motive power in the front rank of modern achievements.

These are only a few of the points of superiority of electric over steam locomotives which have become demonstrated facts so convincing as to justify advancing the claim that the railway problem of today is one of engineering development rather than an unsolvable financial muddle. Make such repairs to steam engines now owned as will take care of immediate needs, but build for future growth of our railway traffic in the knowledge that the steam engine has become obsolete and must give way to the greater possibilities of the powerful and efficient electric locomotive.

T H E F U T U R E O F O U R R A I L W A Y S

The subject of conserving our natural resources has been much discussed in its varied aspects, but no arguments of this nature advanced for the electrification of steam roads have brought constructive results in this land of present unrestricted coal resources unless coupled with positive assurance of an attractive return upon capital expenditure. Electricity derived from water power is utilized because it is cheaper than steam power, but no far reaching sentiment attaches to the fact that the coal burned is unreplaceable. And it is strictly upon an economical basis, also, that electricity is receiving such widespread attention as the preferred source of power to haul our railway trains. Coal can never again be used in the accounts of even the most favored railway at the dollar a ton figure enjoyed before the war, nor will oil at fifty cents a barrel again offer an unsurmountable barrier to the success of electrification plans.

Fuel economy has become a necessity because of its high cost and in this direction the reciprocating steam engine is



TRANSCONTINENTAL PASSENGER TRAIN "OLYMPIAN". CLIMBING THE "ROCKIES"
BEFORE ELECTRIFICATION

a notable offender. This type of prime mover has been driven from the stationary power field by the steam turbine, which also is apparently about to become supreme in ship drive, leaving but one large field monopolized by the reciprocating engine—the haulage of our railway trains.

From test results available, it develops that one-third of the total coal now burned on our steam engines is wasted in so-called stand-by losses. From the moment of firing up to the completion of a day's duty, the steam engine demands continual stoking of coal to keep its boilers hot, whether it is doing useful work in hauling its rated load up grade or on level track, or whether it is standing for hours at terminals or on passing tracks, coasting down long gradients or standing in the round house with fires banked, but still burning coal at a rate of at least three hundred pounds or more per hour. There are some sixty-three thousand steam engines in the country going through this same cycle of losses every day, with no direct supervision of the vast army of firemen employed, each acting independently—some good, some bad—but the average efficiency of them all being so poor that it would bankrupt an electric power company similarly operated and engaged in the competitive business of selling power.

In addition to being burned inefficiently under the steam locomotive boiler, the distribution of railway coal calls for a tonnage movement equal to approximately 20 per cent of the total revenue freight-ton miles carried over the rails of our roads. This statement may appear startling, but it is partly explained by the fact that all coal burned on our steam engines journeys over the road twice—first in the coal car from mine to coaling station, and back again on the engine tender—a third journey is made by the returning empty coal car.

We are quite accustomed to the inclusion of the steam engine tender as quite properly forming part of the complete engine, yet hauling it about adds eleven per cent to the ton mileage of the total revenue freight movement. Bearing in mind that one-quarter of all the coal mined is burned on the railways themselves, its double transportation in car and on tender adds approximately twenty per cent to the ton mileage made by the total revenue freight movement. Practically all of this company coal tonnage movement can be eliminated by the operation of electric locomotives supplied with hydraulic power when available or from steam power stations located at or near mines.

The indictment against the steam engine as a fuel waster is a heavy one. During the year 1918, our railways consumed 163,000,000 tons of coal and 45,700,000 barrels of oil. On the basis that three and one-half barrels of oil is equal to one ton of coal, the equivalent coal consumption during the year 1918 reached the huge total of 176,000,000 tons. It has been estimated that the total wheel movement over our rails, including passenger, gross freight tonnage, locomotive and tenders, approximated 1,215,400,000,000 ton miles during 1918, from which is deducted a coal consumption of 290 lbs. per 1000-ton miles moved.

Based upon operating data now available, it is estimated that 1000-ton miles can be hauled electrically with an expenditure of 40-kilowatt hours, which in a modern generating station can be produced with a consumption of 100 lbs. of coal burned at the rate of two and one-half pounds per kw-hr. It is thus possible to arrive at an approximate measure of the fuel economy that could be effected by electrification of our steam railways. Deducting from the present steam engine movement all company coal tonnage such as coal cars, tenders, etc., a total consumption of 53,500,000 tons is estimated as a rough approximation of the



TRAIN AT SOLDIERS SUMMIT. UTAH, DENVER & RIO GRANDE RAILROAD

amount of coal that would be required to produce the electric power to have hauled the tonnage of 1918 by electric locomotives. This figure indicates a possible saving of 122,500,000 tons of coal as the annual return on universal electrification or two-thirds of the fuel now consumed on the railways in this country. With such a successful example of water power utilization as is afforded by the present electric operation of 670 miles of the Chicago, Milwaukee & St. Paul, it is at once obvious that hydraulic development is destined to play a most important role in the future electrification of our railways, and the above coal saving estimates may be regarded as too low rather than too high.

Many of the present steam engines are antiquated and most inefficient fuel burners, but the improvement resulting from their replacement by modern engines can never approach the fuel savings outlined above while new steam engines will cost nearly as much as the equivalent capacity in electric locomotives. While fuel economy alone may hardly justify the expense of electrification, except in extreme instances, the careful consideration of this subject, however, is both timely and important, as the war period has shown how vitally dependent every country is upon its coal supply.



BUCKING TEST BETWEEN 265-TON GEARLESS PASSENGER LOCOMOTIVE AND 278-TON MALLETT FREIGHT PUSHER. CHICAGO, MILWAUKEE & ST. PAUL—COAST DIVISION

Both the traveling public and the shipper look for better service from the returned railways. Passenger trains must be run on time and freight traffic speeded up before the public will cheerfully co-operate in the matter of increased rates and new capital so necessary to the future stability of our railways. Pouring new money into steam equipment which will duplicate the unsatisfactory performance of that already in service will not meet present or future demands, except at a prohibitive price. The most powerful steam engines of today are pigmies compared to the largest electric locomotives already in operation and much more powerful electric units can readily be built and operated by a single engine crew if the need arises.

Such large passenger locomotives as those just put into operation upon the Seattle extension of the Chicago, Milwaukee & St. Paul are practically immune to climatic conditions. A most spectacular and particularly instructive demonstration was recently given in the form of a tug of war between one of the new electrics and a powerful Mallet steam engine, designed to haul freight over mountain grades. Notwithstanding the fact that the electric locomotive was built for passenger service and can haul a thousand-ton train

at a speed of sixty miles per hour, it developed a starting effort greater than the Mallet freight engine could combat and easily outpulled its steam rival.

Such a powerful and flexible type of motive power as this electric locomotive gives a hitherto unknown assurance that passenger trains will be run on schedule time, regardless of temperature changes, independent of rail conditions and free from the vagaries of firemen and steaming qualities of fuel. It has the pulling power of a freight engine coupled with the high speed characteristics proper to level track schedules. In fact, the gearless electric locomotive just put into operation on the Cascade division of the Chicago, Milwaukee & St. Paul railway fully measures up to the varied requirements of a real passenger locomotive that must run equally well throughout the year over a broken profile comprising such extremes as a seventeen-mile ruling gradient of 2.2 per cent and many others of lesser magnitude connected by stretches of level track.

It requires no helper to assist in hauling twelve steel cars weighing one thousand tons against the 2.2 per cent ruling grade at 25 miles per hour, and is equally capable of reaching a speed of 60-65 miles per hour with the same train on level track. Finally, to complete its wonderful fitness for mountain grade operation, it provides electric braking on the long, severe down grades. Not only is the safety of mountain railroading greatly enhanced by the complete elimination of dangerous heating of wheels and brake shoes, inseparable to the protracted use of air brakes, but the regenerative feature of electric braking actually returns electricity to the trolley system. The resulting reduction in power bills on the Chicago, Milwaukee & St. Paul is approximately 15 per cent. In other words, electric operation practically eliminates the dangerous and costly features of mountain grades so much dreaded by the steam engine operator.



FREIGHT TRAIN DESCENDING 2 PER CENT GRADE ON EASTERN SLOPE OF THE ROCKIES.
CHICAGO, MILWAUKEE & ST. PAUL RAILROAD

No other type of motive power can offer such promise of greatly widening "the neck of the bottle" without materially adding to present track facilities. In this connection the fact should not be disregarded that these advantages of electric operation have all been demonstrated on the changed over divisions of a scant half dozen roads, leaving much room for further advance in the art following its more extensive application.

While improvements in passenger service are most important and greatly appreciated by the traveling public, freight receipts constitute seventy-five per cent of railway income and largely determine the nature and extent of capital expenditure for betterments. There are two factors that conspire to limit the weight of train that can be hauled by one engine over a mountain division: per cent of ruling grade and strength of draw bars. The necessity of increasing the daily tonnage carried over a single track division has resulted in raising train weights to the maximum possible with present limits of draft gear. Steam engine hauling power has kept pace with improvement in strength of cars and has given rise to the Mallet type of construction, the

largest of which will deliver a starting effort of 150,000 lbs. Such large units, however, must act as pushers at the rear of a train, as draw bars have not reached the stage of development permitting such pulls under tension.

It would appear to the casual observer that the requirements of mountain railroading have been reasonably well met by the steam engine available today, were it not for the comparison offered by the results of electric operation. While the Mallet is capable of giving great tractive power, it is, however, accomplished at the sacrifice of speed, which approximates only six to eight miles per hour on ruling grade. To reach the fifteen or more miles per hour reached with a single electric locomotive operating under similar conditions would necessitate running two or more Mallet engines with the prohibitive operating expenses inseparable to such excess of engine power. In other words, no steam engine can be built and operated with a single crew that will provide such a combination of great tractive effort



DETROIT RIVER TUNNEL ELECTRIC LOCOMOTIVE HAULING 1400-TON FREIGHT TRAIN



NEW YORK CENTRAL RAILROAD ELECTRIFICATION. THE "20TH CENTURY LIMITED"
LEAVING NEW YORK CITY

and speed as is entirely practicable in electric locomotive construction.

The steam engine on heavy grades loses some 12 per cent of its effectiveness in revenue hauling capacity by being compelled to haul its own coal on tender and coal cars. The equivalent of one train in every eight is required to haul its own fuel, a matter of serious concern on a congested division.

The rigid wheel base of the more powerful steam engines may reach 21 ft., which is entirely too great for successful running on the ten degree curves so often necessary on mountain divisions. Electric locomotives of equal pulling power require but half this wheel base, a fact which is reflected in the lower maintenance of both track and locomotive.

It has apparently been demonstrated beyond doubt that the electric locomotive can be maintained at materially less expense than a steam engine of equal capacity. Even under present high prices, the Chicago, Milwaukee, & St. Paul electric freight locomotives are being kept in repair for



SMOKE CONDITIONS AS THEY EXISTED AT THE GRAND CENTRAL TERMINAL, NEW YORK CITY, IN 1906

approximately 13 cents per mile run, while Mallet engines are costing from 30 to 50 cents for similar service.

In an abridged discussion of this length the many advantages of electrification have, necessarily, been but slightly touched upon. The facts available, however, will bear the most critical analysis and clearly bring out the two features dwelt upon herein at some length, the enormous fuel saving and far reaching improvements in service resulting from the substitution of electric for steam locomotives. Electrification offers a means of meeting the emergency brought about by present inadequate transportation facilities. It involves no experiment with novel and untried apparatus. On the contrary, universal electrification could well closely follow along the lines of installations now in successful operation. Future development will direct the adoption of detail changes, but offers small opportunity to bring about any fundamental improvements that will call for the untimely retirement of such an efficient mechanism as the 300-ton locomotives now operating on the Chicago, Milwaukee & St. Paul railway at an upkeep expense of 13 cents per mile and in which electricity is transformed into mechanical power with an efficiency of nearly 90 per cent.

The extensive electrification plans of England, France, Italy, Belgium, Switzerland and other countries are sufficient



GRAND CENTRAL TERMINAL, NEW YORK CITY, LOOKING FROM 48TH STREET, SHOWING RESULTS OF ELECTRIFICATION

evidence of appreciation of its benefits abroad. Government and railway executives are fully in accord in this matter and are working jointly to bring about its early fulfillment.

We are justly proud of the greatest railway system on earth. Both in extent and low cost of operation it stands supreme, and this enviable position is vitally necessary to the future welfare of the country's most fertile expanse placed a thousand miles to either ocean. But in the coming competition for the world's markets we are threatened with serious disaster if our rail highways are not kept in the highest state of efficiency. A newer and more powerful motive power than the steam engine has been developed and tried out with resulting benefits of such fundamental character as to command instant attention of both railway operators and financiers. In answer to the question of "what is the matter with our railways," it may be said that they are suffering from physical stagnation produced by the fact that steam engine development has not kept pace with the needs of modern transportation.

The most effective known remedy is the immediate electrification of the more difficult divisions where the limitations of the steam engines are most keenly felt and the future extension of the electrified zones to meet progressive needs. Such betterments can be made in the knowledge that

T H E F U T U R E O F O U R R A I L W A Y S

the electric motor is pre-eminently fitted to meet the varied requirements of future unlimited railway expansion and render adequate return both to the operator and investor in railway securities.



TRANSCONTINENTAL PASSENGER TRAIN IN THE ELECTRIC ZONE OF THE GREAT
NORTHERN RAILWAY, CASCADE TUNNEL, WASHINGTON



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